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ABSTRACT

Designed for fifth grade mathematics teachers, the three inservice sessions described in this booklet balance the theoretical with the practical and show teachers how to help students through the activity of writing word problems based on their own experiences. Using a total language-thinking approach to helping students read and solve word problems, the first section, entitled "Language," involves teachers in demonstration lessons with students and discussions with other teachers on the relationship between reading and mathematics, the special language of mathematics, and the growth of language through the use of language. The second session, "Thinking," contains information on Jean Piaget's three stages of thought. It emphasizes the need for teachers to focus not only on language that promotes mathematical reading ability, but also on promoting and encouraging competent problem solving skills through a conscious attempt to teach for thinking. The third session, "Computation," involves the teachers in reviewing the content of the previous two sessions, going through the steps of solving problems, and spending time with other teachers discussing their successes, failures, and questions related to reading word problems in classrooms. An evaluation form, additional ideas and activities for student-developed word problems, and a list of references are included. (RI)

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A LANGUAGE-THINKING APPROACH TO MATHEMATICAL PROBLEM SOLVING:

A STAFF DEVELOPMENT PACKAGE

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FOREWORD

The authors of this package believe that reading is a "language-thinking" process. The reading approach which will be the most successful is one which focuses on the total language of the child, his thinking processes, and the experiences he brings with him to a learning situation. Children can overcome repeated failure with word problems using a language-experience approach since LEA focuses on just the areas children have the most trouble:

1. Low reading comprehension
2. Lack of experience with the problem situation
3. Unfamiliarity with the language of the problem
4. Irrelevancy of the problem

When children are guided through the activity of writing word problems based on their own experiences, these four problems are eliminated.

This staff development package is an attempt to look at the difficult problem of helping children to read and solve word problems by taking a total language-thinking approach to word problems. Children will be more successful with reading word problems if teachers begin with the child's language and his patterns of thinking in solving problems.

The three inservice sessions described within are an attempt to balance the theoretical with the practical. Teachers need a sound theoretical base from which to make assumptions about classroom practices. In addition, fresh practical ideas can sometimes brighten even the dullest inservice program.

Finally, the authors believe that one of the strongest selling features of a staff development program is teacher involvement. Teachers need to be, and should be, involved with the planning and presentation of staff development programs.

Special thanks go to Mrs. Ruby Smith, principal at South Side Elementary School in West Point, Mississippi, who so graciously coordinated our efforts to field test this inservice program.

OBJECTIVES

The objectives are:

1. to present a "total language" approach to solving children's problems in reading mathematical materials;

2. to present a conceptual base for children's thinking patterns and development based on Piagetian principles;

3. to present practical ideas and teaching suggestions which utilize a whole language approach;

4. to involve teachers in using with their own classes, ideas gained from the staff development programs;

5. to involve children in the workshops to demonstrate successful classroom practices.

DESCRIPTION

This package is designed for fifth grade mathematics teachers. The program has three strands:

I. Language
II. Thinking
III. Computation

It is intended that each strand should be the focal point for one staff development session of one hour in length. It may be more convenient to schedule one hour meetings three consecutive weeks, and this package has been designed on this premise. However, the time element is flexible and could be adjusted to two one and one-half hour sessions.

For each strand, a teaching demonstration component is included. A small, workable group of fifth graders is asked to participate in a fifteen to twenty minute lesson which centers around the subject to be discussed by the teachers during that inservice period. The teacher of this demonstration group should be a master teacher who has helped with the planning stages of the inservice implementation. This demonstration forms the experience, or basis upon which all discussion and lecture for that session is focused. Each session's demonstration lesson will be outlined by a black box.

Subsequent discussion focuses around the principles demonstrated in the "mini-lesson". At the end of each session, teachers are asked to select or adapt from the activities given or create their own activities to practice the ideas and principles discussed in the program.

A LANGUAGE-THINKING APPROACH TO MATHEMATICAL PROBLEM SOLVING

Session I: Language

Introduction:

1. Explanation of need for workshop: objectives.
2. Explanation of three strands which comprise workshop: language, thinking, computation.
3. Explanation of demonstration component and introduction of master teacher.

Demonstration Lesson:

In this lesson, story problems become the vehicle for the use of the language experience approach.

Discussion is initiated with questions such as:

Do you receive an allowance? How much?
Do you eat out often, using your allowance?
Do you eat out with friends?
Where is your favorite place to eat? Why?
What would you consider to be a balanced meal?

Materials Provided:

Laminated menus (McDonald's), grease pencils, paper, pencils, tape recorder and McDonald's place mats.

Setting Purpose:

We will be making up word problems using our own past experiences (eating at McDonald's), and utilizing the menus provided.

Before assigning the task, the teacher should go through the process of making up a sample problem. "Pizza Hut" menus are used; the children are able to see the menus as the word problem is verbalized. The essential information is given for the problem, then the children are asked what steps would be taken in solving that problem. The problem is then written for them to see.
(See problem on next page.)

> Judy and Pat went to Pizza Hut for dinner. They shared a medium size pizza at $5.30 and each had a single salad at $.95. How much did each girl pay?
>
> After seeing the sample, the children are paired to work on their own problems and given only two guidelines: they must order a balanced meal and use an amount of money appropriate to the occasion.
>
> The children use the laminated menus and grease pencils to note the items ordered. Later, these same menus will be used when writing the problem.

After viewing the demonstration lesson by the master teacher, the other teachers begin their "lessons" with presentations concerning the relationship between reading and mathematics, the special language of mathematics, and the growth of language through the use of language.

OVERVIEW OF THE READING PROCESS AS IT RELATED TO MATHEMATICS

1. Show the transparency "Nonsense Word Problem" (page 7); ask teachers to read and work the problem. Discuss what the teachers <u>are</u> able to discern and why.

2. Show the transparency entitled "Cue Systems" (Kenneth Goodman) (page 8). Discuss with teachers how each subsection relates to the math word problem (some areas will "fit" much easier than others, but this overview shows very nicely the areas we might use to "get meaning from print".)

3. Optional. Depending on the needs of your teachers, you may wish to use "Reading Skills Used in Mathematics" as a transparency or handout (page 9). However, the balance of this packaged inservice is not dependent on the teachers understanding the concepts involved in "reading skilling".

THE LANGUAGE OF MATHEMATICS

In teaching the vocabulary of math, the teacher should introduce words as vocabulary words would be introduced in a reading lesson. Many educators believe that using the whole word approach, words in context, and words by definition are excellent methods of teaching vocabulary in

NONSENSE WORD PROBLEM

Ft. Zlect glepped 3 planwums di clump tid $14.40. Esse planwum blad hedd nan fruttle. Ruse blad hedd fruttle di esse planwum?

Mr. Brown bought 3 cans of paint for $14.40. Each can was the same price. What was the price of each can?

CUE SYSTEMS

I. CUES WITHIN WORDS
   - A. LETTER - SOUND RELATIONSHIPS
   - B. WORD CONFIGURATIONS
   - C. LITTLE WORDS IN LARGER WORDS
   - D. AFFIXES
   - E. RECURRENT SPELLING PATTERNS
   - F. WHOLE KNOWN WORDS

II. CUES WITHIN THE FLOW OF LANGUAGE
   - A. PATTERNS OF WORD ORDER
   - B. INFLECTION AND INFLECTIONAL AGREEMENT
   - C. FUNCTION WORDS
   - D. INTONATION
     1. JUNCTURE
     2. STRESS
     3. PITCH
   - E. CONTEXT
   - F. REDUNDANCY IN LANGUAGE

III. CUES WITHIN THE READER
   - A. LANGUAGE FACILITY
   - B. DIALECTICAL DIFFERENCES
   - C. PHYSICAL FACTORS
   - D. LEARNED RESPONSES TO GRAPHIC CUES
   - E. EXPERIENTIAL BACKGROUND
   - F. CONCEPTUAL BACKGROUND

IV. EXTERNAL CUES
   - A. PICTURES
   - B. PROMPTING
   - C. CONCRETE OBJECTS
   - D. SKILL CHARTS

READING SKILLS USED IN MATHEMATICS

I. Vocabulary and Word Recognition Skills
   - A. Structural Analysis
     1. Prefixes
     2. Suffixes
     3. Root words
   - B. Context Clues
   - C. Dictionary
     1. Math dictionary
     2. Glossary
     3. Standard dictionary - multiple meanings of words
   - D. Sight Vocabulary
     1. Specialized vocabulary
     2. Symbols
     3. Abbreviations
     4. Geometric figures
     5. Other

II. Comprehension Skills (Used in all math reading - especially important in problem solving)
   - A. Main Idea
   - B. Significant Details
   - C. Following Directions
   - D. Cause and Effect
   - E. Translating Mathematical Sentences

III. Rate
   - A. Skimming and Scanning
   - B. Slow Pencil and Paper Reading

IV. Study Skills in Math
   - A. Textbook Handling
     1. Format
     2. Table of Contents
     3. Index
     4. Appendices
     5. Glossary
     6. Answers (if any)
   - B. Tables
   - C. Graphs
   - D. Charts
   - E. Others when applicable

mathematics. To reinforce new vocabulary, posters, chalkboard, and symbols could be utilized. Math vocabulary could also be listed in daily spelling words.

Included in the math vocabulary are clue words such as "sum", "double", "times", and "in all" which give students hints as to which operation should be performed. These are vital vocabulary words in math and should not be left to happenstance. Teachers need to prepare well-structured lessons for the introduction of these special vocabulary words. After introducing these words, a few activities to reinforce would be appropriate. The following two activities have been helpful to teachers in reinforcing clue words. They are also easy to reproduce and simplified for student independent use. (During the inservice session, teachers may actually work through these activities as preparation for using them in the classroom.)

Clue Concentration

Materials needed: construction paper, flash cards -- one group of cards has clue words printed on them; for each clue word card you would have a matching card with the basic operation word printed on it (addition, subtraction, multiplication, division)

You could use as many sets as you like. The following sixteen (16) clue words can be used in the concentration game:

total	average	twice	minus
sum	plus	double	quotient
difference	in all	product	times
add	take away	give away	per

The purpose of the game is to match the clue word and the basic operation word card. Place all face-down in rows. Each player has a turn, the player turns up two cards, if they match,

then the player keeps the pair. If the cards do not match then the cards are turned back over. The player with the most pairs at the end of the game is the winner.

Clue Fishing

Materials: cut-out fish shapes from construction paper, a paper clip attached to each fish (approximately 16), container: (for fish) an old coffee can will do, and something to be used as a fishing pole (a pencil, string) and a magnet.

Directions: (These can be printed on paper and attached to outside of coffee can.)

The number of players vary, but you need one to be monitor or checker.

1. Each player takes a turn going fishing.
2. When fish is caught, look at the clue word printed on the fish.
3. Decide for which basic operation this is a clue and tell your fishing partner.
4. Monitor checks the answer key on the bottom of the fishing can -- the number on the back of the fish matches numbers listed under one of the four (4) basic operations.
5. Keep the fish if your answer is right, toss it back if wrong.
6. Fisherman with most fish at the end of the game is the winner.

LANGUAGE GROWTH THROUGH LANGUAGE USE

Math language/vocabulary will grow through a conscious use of language-oriented activities. Discuss with teachers possible activities which would focus on language and math and would precede or follow-up the menu activity presented in the first demonstration lesson. As each activity

is suggested, discuss with the teachers how and why the activity would develop math language. (See the section called "Activities" for suggested menu activities on page 22).

Session II: Thinking

Introduction:

1. Preview Session II staff development program and strands.
2. Review the first session on language.

Demonstration Lesson:

Discussion is initiated about clue words, and how they help us determine the process to be used in problem solving.

The students then write their own word problems. The next step is to read over the problems and check to see which clue words are used. The problems are then tape recorded for replay.

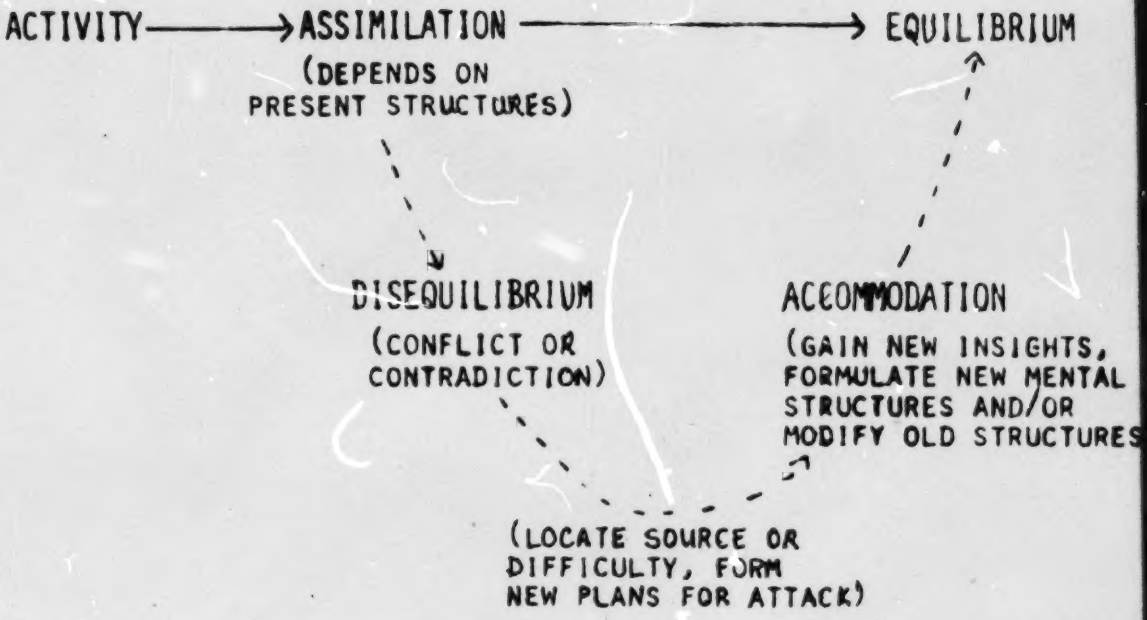
The problems are replayed and the students go through the thinking process of solving each.

Following the children's demonstration lesson, the teachers begin their inservice program with a presentation on teaching for thinking followed by Piaget's Three Types of Knowledge, and Implications for the Classroom.

TEACHING FOR THINKING

Basic to all of Piaget's work on his theory of the development of reasoning is the idea of mental structures (see page 14). Structures are "blueprints" which guide our behavior. When we are born we have very few mental structures, but as we grow and experience life we form new structures and reconstruct old ones. This construction, or reconstruction of mental structures, is fundamental to learning. These structures determine what reasoning patterns we use and determine how we interact with our environment. Piaget calls the process of constructing new mental structures, self-regulation.

SELF-REGULATION



The first step in self-regulation is assimilation. We perceive a given situation or activity and give it meaning which is consistent with our present mental structures. When a situation does not appear to fit our present mental structures, it causes confusion, or what Piaget calls a state of disequilibrium or a "cognitive conflict". Piaget feels that this confused state is the root of all learning.

In a state of disequilibrium, an individual attempts to locate the source of the problem and form a plan of attack. Each person's approach to solving a problem will vary since each one of us have different mental structures. When the plan of attack is successful, new mental structures are formed and a state of accommodation is achieved. In this state, the individual has gained new insights, modified old mental structures, and can now be considered to be in a state of equilibrium.

PIAGET'S THREE TYPES OF KNOWLEDGE*

Piaget describes three basic types of knowledge as follows.

1. The first is a result of sensorimotor intelligence. This includes instinctive-type behavior such as sucking, blinking and kicking.

2. A second type is physical knowledge. It is a factual type knowledge based on senses, such as what we see or hear. For example, we hear birds sing, but we may not be able to generalize that only some birds sing. This involves a logical thought structure characteristic of the next level of knowledge.

3. The third and highest form of cognitive function is known as logico-mathematical. This knowledge develops out of an inter-action of our physical experiences and our logical mental processes. This knowledge develops in stages and is largely an internal process.

*The bulk of the Pigetian materials in this section are adapted from Richard Copeland's *Math Activities for Children*, 1979.

The problem of teaching logico-mathematical knowledge, then, is placed in a new context. Johnny may not be able to learn certain ideas regardless of how he is stimulated until a certain point in time when he has the necessary mental structures.

Piaget listed four basic levels of intellectual development in children along with a number of substages. They are:

0-2 years	Sensorimotor
2-7 years	Preoperational
7-11 or 12 years	Concrete Operational
11 or 12 years on	Formal Operational

The ages given are approximations and may vary from activity to activity.

The preoperational level is prelogical or premathematical, in that the child cannot understand basic mathematical concepts as conservation of number and addition. Responses are usually based on perceptional cues rather than appropriate logical processes.

At the concrete operational level the child uses logical or reasoning processes as a basis for an answer. The child still needs to work with objects in order to formulate reasoning processes at this level.

The next level, formal operational, involves being able to think directly in the abstract.

For the activities explained in this session the responses are described as Stage 1, Stage 2 and Stage 3. Stage 1 responses are at the pre-operational level; these responses involve no understanding. Stage 2 is a transitional one between the preoperational and concrete operational. The student works by trial and error to get the correct answer. At Stage 3, responses are immediate and correct. Although this package doesn't address higher level problems, there is a Stage 4 that corresponds

to the formal operational level. Stage 4 children are able to think at the abstract or theoretical level to formulate rules.

In conducting the activities for diagnostic and developmental purposes, if a child is in Stage 1, allow several weeks of developmental time before considering the task again. If Stage 2, provide a variety of activities related to the same concept over a period of several weeks. If Stage 3, the child is ready for the related instructional process.

The seven mathematical content areas have been described as follows:

Logical Classification - Some classification activities should precede number activities.

Number - To understand number, children must understand the concept of conservation. They must also understand the concept of ordering (seriation) and that of class inclusion.

Space Orientation - The concepts of horizontal and vertical are not abstracted until around 9 years of age. Yet these concepts are necessary for organizing spatial thinking. Spatial exploration of such ideas as sets of objects and number line also serves as a basis for abstracting number ideas.

Measurement - Developmentally, children are not fully operational with respect to some measurement concepts until 11 or 12 years of age.

Knowing Versus Performing Mathematics - Knowing how to give the answer in an addition problem is not the same as knowing what addition is. Being conscious of or understanding a logicomathematical process may lag by six years being able to "perform" the operation correctly.

Mathematical Memory - Memory is often thought of as storing what is seen or heard. Piaget found that a certain developmental level must be reached for children to remember what they have seen if a logical mathematical process is involved. Then memory is what the mind can reconstruct of that to which it has been exposed.

Chance and Probability - "Why" questions demand a reason even when there are none. Many questions little children ask have no rational explanation. Chance as a cause of events is not even realized by young children.

IMPLICATIONS FOR THE CLASSROOM

In addition to focusing on language to promote mathematical reading ability, teachers need to focus as well on promoting and encouraging competent problem solving skills through a conscious attempt to teach for thinking. This may best be approached through a discussion of the article "Teaching for Thinking: A Piagetian Perspective" which appeared in *Today's Education* (v. 65, n. 3) in the September-October issue, 1976 (pp. 38-41). (See page 19.)

Teaching for Self-Regulation: Some Practical Suggestions. Although some of the following suggestions are not direct consequences of Piaget's theory, we believe they are all compatible with a Piagetian perspective.

1. Arrange your teaching sequence so that you begin with concrete ideas defined through demonstrations, examples and actions. Present more formal definitions of the same ideas to the class at a later time.

2. Use student exploration activities before introducing a new concept. At this time and on other occasions, give students opportunities to work with objects and make observations in an environment that allows them to ask their own questions and follow their own interests.

3. Begin class discussions with simple demonstrations and challenge students to raise questions or predict outcomes of experiments. Then use the actual results for initiating an examination of unexpressed assumptions or expectations.

4. Encourage students to interact with one another during discussions, laboratories, and problem-solving sessions. By learning the viewpoints of others, they will become more aware of their own reasoning. Students who use formal reasoning patterns will serve as role models for those who do not. The latter, because of their more limited understanding, will challenge the formal reasoners' shortcuts in reasoning, thus making them rethink their ideas.

   Furthermore, students who would not ask the teacher "stupid" questions may raise those questions with their peers. Then their peers can deal with conceptual difficulties that the concrete thinkers might never have revealed.

5. Ask students to justify their conclusions, predictions, and inferences regardless of whether these are correct or incorrect. "Why are you sure of that?" "What is the evidence?" "How could you explain that to me?" "What other ways of thinking about that problem are there?" are questions that might get them thinking.

6. Try to be as receptive as possible to apparently off-the-track ideas or hypotheses. Don't squelch a timid first attempt, but encourage it by drawing attention to its good or unusual points. Suggest an activity--an additional reading, perhaps--to help a student reexamine an inadequate reasoning pattern or preconception. Emphasize the reasons behind an answer rather than the "right answer" itself.

7. Our last suggestion is in many respects the most important one. Be willing to reason out loud and to reveal that you are at times unable to proceed with a problem. Propose a variety of hypotheses, consider alternatives, deduce implications, and examine evidence. Be willing to leave some questions unanswered. Lose your fear of loose ends. Model the reasoning behavior you hope to foster in your students.

...from "Today's Education," NEA, ..., September-October, 1974, pp. 38-41.

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Session III: Computation

Introduction:

1. Review last two sessions and strands briefly.

Demonstration Lesson:

At the beginning of this session, a review of the previous two sessions is necessary. The taped problems are replayed to refresh the students' memories. Time is allowed to check over the word problems that had been written and to go over the steps used in solving the problems.

A worksheet containing all of the problems is given to the students.

While students are working on the problems, the teachers go through the steps of solving problems as stated by D. Moseley, Mississippi State Department of Education.

They are:

1. Get to know the problem. Read carefully, determine exactly what is being asked.
2. Choose what to do. Decide which operation is to be used by using clue words.
3. Do it. Write a simple equation. Solve the problem.
4. Look back. Check answer using inverse operation.

The remainder of the session is used for teacher questions and feedback. Teachers are also encouraged to report on successes and failures of reading word problems in their classrooms.

EVALUATION

An evaluation of each session gives feedback to the leaders involved in the inservice activities. They can tell whether each session is reaching the objective of helping teachers to teach students how to successfully solve reading word problems.

A simple form is used to determine whether the process in the in-service sessions is effective and, if not, to decide what changes must be made to insure its effectiveness.

PROGRAM EVALUATION FORM

I. Please evaluate the program in the areas listed below:

	Poor	Fair	Good	Excellent
Pertinent to my needs and interests	____	____	____	_____
Usefulness of the information	____	____	____	_____
Balance between theory and practical ideas	____	____	____	_____
Clarity of material	____	____	____	_____
Manner of Presentation	____	____	____	_____

Comments:

ACTIVITIES

INVOLVING EXPERIENCES

There are many ways to involve children in experiences which can later serve as the springboard for math problems. A few are listed below and your teachers can add many more.

1. Buying and selling cars using motor company brochures and newspaper ads.
2. Using dominos, marbles, and other simple games to illustrate probability and geometric concepts.
3. Set up a grocery store in a corner of your room.
4. Allow the students to prepare and collect orders for paperback books.
5. Allow the children to prepare the lunchroom order and collect the money.
6. Using large department store catalogs, plan and order Christmas or birthday gifts.
7. Plan an Easter egg hunt; decide upon the best buy on eggs and figure cost per child.
8. Go to the bank and take out a loan to pay for a field trip or a classroom pet.

MORE "MENU" IDEAS

Menus are a great source of problems. For example, how much more is a cheeseburger than a fish sandwich; what combinations of orders could you place if you only had a dollar (do not forget the sales tax); how many small colas could you buy with $4.00?

There are a myriad of practice ideas using the four basics:

Addition

List pairs of sandwiches and drinks and find the totals for each. Add the orders of your classmates for a grand total.

Subtraction

How much more is a superburger than a heftyburger? Large cola than a small cola? Banana split than a sundae? If you bought a vanilla shake with 3 quarters, how much change would you bet back?

Multiplication

If 3 of your friends bought a burger and a cola, what would the cost be? How much would seven large mushroom pizzas cost? If everyone in your class bought the seafood platter, what would the total come to?

Division

If you share a large salad and a small pizza supreme with your best friend, how much would you each pay? How many orders of french fries can you buy with $5.35?

-- Problems can also be combined to form multi-step problems and graphing projects can also be included with menu activities.

-- Students might design their own menus.

-- Write stories and poems about foods.

-- Write radio ads for restaurants and tape them.

-- Draw posters advertising the restaurant.

-- Write to friends and relatives in other parts of the country requesting menus, then compare prices.

-- Investigate the nutritional composition of foods and classify by percentage.

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